

**AMENDMENTS TO THE CLAIMS:**

**Complete Listing of Claims**

1    Claim 1. (currently amended)     A microcontroller integrated circuit (IC)  
2    comprising:  
3         a program memory for storing a program to be executed;  
4         a program counter coupled to the program memory for selecting address  
5    locations in said memory;  
6         a program counter copy register for storing a program memory address  
7         pointed to by said program counter as a return address from a debug monitor  
8         routine;  
9         instruction execution circuitry coupled to the program memory for  
10   executing instructions received from said memory;  
11         a breakpoint address register for storing a breakpoint address;  
12         address compare circuitry for comparing a value in said program counter  
13   to a value in said breakpoint address register, said compare circuitry providing a  
14   breakpoint signal upon detection of a valid breakpoint address comparison; and  
15         a multiplexer interposed between said program memory and said program  
16   execution circuitry, said multiplexer comprising circuitry for inserting a debug  
17   instruction into the instruction execution circuitry upon receipt of said breakpoint  
18   signal, wherein said debug instruction is substituted for an instruction in a  
19   program memory address pointed to by said program counter.

1    Claim 2. (original)   The microcontroller IC of claim 1, further comprising:  
2       a stack pointer register;  
3       a stack breakpoint register for storing a stack trap address;  
4       stack pointer compare circuitry for comparing a value in said stack pointer  
5   register to a value in said stack breakpoint register, said stack pointer compare  
6   circuitry providing a stack trap signal upon detection of a valid stack pointer  
7   address comparison; and  
8       wherein said multiplexer inserts said debug instruction into the instruction  
9   execution circuitry upon receipt of said stack trap signal.

1    Claim 3. (original)   The microcontroller IC of claim 2, wherein said valid stack  
2   pointer address comparison is selected from the group consisting of: said value  
3   in said stack pointer register being equal to said value in said stack breakpoint  
4   register, said value in said stack pointer register being greater than said value in  
5   said stack breakpoint register, said value in said stack pointer register being less  
6   than said value in said stack breakpoint register, and combinations thereof.

1    Claim 4. (original)   The microcontroller IC of claim 1, further comprising single  
2   step circuitry directing said multiplexer circuitry to insert said debug instruction  
3   into the instruction execution circuitry after the execution of each instruction of an  
4   application program.

1    Claim 5. (original)   The microcontroller IC of claim 1, wherein said debug  
2   instruction is a long jump instruction to a debug monitor routine.

Claim 6 (canceled)

1      Claim 7. (original)   The microcontroller IC of claim 1, wherein said address  
2      comparison circuitry further comprises memory bank comparison circuitry for  
3      detecting a specific bank access in addition to said breakpoint address.

1      Claim 8. (original)   An embedded microcontroller apparatus comprising:  
2                a circuit board embedded in the apparatus;  
3                a microcontroller integrated circuit disposed on said circuit board,  
4      including :  
5                a program memory for storing a program to be executed,  
6                a program counter coupled to the program memory for selecting address  
7      locations in said memory,  
8                a program counter copy register for storing a program memory address  
9      pointed to by said program counter as a return address from a debug monitor  
10     routine, and  
11                debug circuitry disposed on said microcontroller integrated circuit, said  
12      debug circuitry comprising  
13                compare circuitry for comparing a breakpoint address to instruction  
14      fetch addresses in said program memory, said compare circuitry  
15      generating a breakpoint signal indicating a valid address compare; and  
16                multiplexer circuitry coupled to said compare circuitry, said  
17      multiplexer circuitry, upon receiving said breakpoint signal, substituting a  
18      debug program instruction for execution by the microcontroller in place of  
19      a standard instruction fetched from program memory.

1      Claim 9. (original)   The embedded microcontroller apparatus of claim 8,  
2      wherein said apparatus is a universal serial bus controller.

1    Claim 10. (original) The embedded microcontroller apparatus of claim 8,  
2    wherein said microcontroller further comprises a stack pointer register, and said  
3    debug circuitry further comprises:  
4         a stack breakpoint register for storing a stack trap address; and  
5         stack pointer compare circuitry for comparing a value in said stack pointer  
6    register to a value in said stack breakpoint register, said stack pointer compare  
7    circuitry providing a stack trap signal upon detection of a valid stack pointer  
8    address comparison; wherein said multiplexer substitutes said debug program  
9    instruction for execution by said microcontroller upon receiving said stack trap  
10   signal.

1    Claim 11. (original) The embedded microcontroller apparatus of claim 10,  
2    wherein said valid stack pointer address comparison is selected from the group  
3    consisting of: said value in said stack pointer register being equal to said value in  
4    said stack breakpoint register, said value in said stack pointer register being  
5    greater than said value in said stack breakpoint register, said value in said stack  
6    pointer register being less than said value in said stack breakpoint register, and  
7    combinations thereof.

1    Claim 12. (original) The embedded microcontroller apparatus of claim 8, said  
2    debug circuitry further comprising single step circuitry directing said multiplexer  
3    circuitry to substitute said debug program instruction for execution by said  
4    microcontroller after the execution of each standard instruction fetched from  
5    program memory.

1    Claim 13. (original) The embedded microcontroller apparatus of claim 8,  
2    wherein said debug program instruction is a long jump instruction to a debug  
3    monitor routine.

Claim 14 (canceled)

1    Claim 15. (currently amended) A method of debugging a microcontroller  
2    integrated circuit, said method comprising:  
3         storing a breakpoint address in a hardware register on said microcontroller  
4    integrated circuit;  
5         executing an application program from program memory by said  
6    microcontroller;  
7         comparing application program instruction addresses to said breakpoint  
8    address;  
9         halting execution of said application program upon detection of an  
10   instruction fetch from a memory address equal to said breakpoint address;  
11         storing said memory address in a program counter copy register, wherein  
12   said address is reloaded into said program counter after execution of said debug  
13   routine;  
14         substituting a jump instruction to a debug program for said instruction  
15   fetched from said memory address; and  
16         executing said debug program.

1    Claim 16. (original) The method of claim 15, further comprising:  
2         storing a stack trap address in a stack breakpoint hardware register on  
3    said microcontroller;  
4         comparing stack pointer addresses to said stack breakpoint address; and  
5         upon detection of a valid stack pointer address comparison, performing  
6    said halting execution, said substituting said jump instruction, and said executing  
7   said debug program steps.

1    Claim 17. (original) The method of claim 16, wherein said valid stack pointer  
2    address comparison is selected from the group consisting of: said stack pointer  
3    address being equal to said stack breakpoint address, said stack pointer address  
4    being greater than said stack breakpoint address, said stack pointer address  
5    being less than said stack breakpoint address, and combinations thereof.

1    Claim 18. (original) The method of claim 15, said executing said debug program  
2    comprising:  
3         providing status information to external circuitry; and  
4         receiving new breakpoint address information.

Claim 19 (canceled)

1    Claim 20. (currently amended) The method of claim 15 19, further comprising  
2    pushing the address stored in the program counter copy register onto a stack  
3    and executing a return to said application program at a location pointed to by  
4    said memory address.